

NODE=B082

 $\Delta(1620)$ $1/2^-$

$I(J^P) = \frac{3}{2}(\frac{1}{2}^-)$ Status: * * * *

Most of the results published before 1975 were last included in our 1982 edition, Physics Letters **111B** 1 (1982). Some further obsolete results published before 1984 were last included in our 2006 edition, Journal of Physics, G **33** 1 (2006).

NODE=B082

 $\Delta(1620)$ BREIT-WIGNER MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1600 to 1660 (\approx 1630) OUR ESTIMATE			
1600 \pm 8	ANISOVICH	12A	DPWA Multichannel
1615.2 \pm 0.4	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1620 \pm 20	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
1610 \pm 7	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1600 \pm 1	SHRESTHA	12A	DPWA Multichannel
1625 \pm 10	ANISOVICH	10	DPWA Multichannel
1650 \pm 25	THOMA	08	DPWA Multichannel
1614.1 \pm 1.1	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
1612 \pm 2	PENNER	02C	DPWA Multichannel
1617 \pm 15	VRANA	00	DPWA Multichannel
1672 \pm 5	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
1617	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
1669	LI	93	IPWA $\gamma N \rightarrow \pi N$
1672 \pm 7	MANLEY	92	IPWA $\pi N \rightarrow \pi N & N\pi\pi$
1620	BARNHAM	80	IPWA $\pi N \rightarrow N\pi\pi$
1712.8 \pm 6.0	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
1786.7 \pm 2.0	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$
1580	² LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
1600	³ LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

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 $\Delta(1620)$ BREIT-WIGNER WIDTH

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
130 to 150 (\approx 140) OUR ESTIMATE			
130 \pm 11	ANISOVICH	12A	DPWA Multichannel
146.9 \pm 1.9	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
140 \pm 20	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$
139 \pm 18	HOEHLER	79	IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
112 \pm 2	SHRESTHA	12A	DPWA Multichannel
148 \pm 15	ANISOVICH	10	DPWA Multichannel
250 \pm 60	THOMA	08	DPWA Multichannel
141.0 \pm 6.0	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$
202 \pm 7	PENNER	02C	DPWA Multichannel
143 \pm 42	VRANA	00	DPWA Multichannel
147 \pm 8	ARNDT	96	IPWA $\gamma N \rightarrow \pi N$
108	ARNDT	95	DPWA $\pi N \rightarrow N\pi$
184	LI	93	IPWA $\gamma N \rightarrow \pi N$
154 \pm 37	MANLEY	92	IPWA $\pi N \rightarrow \pi N & N\pi\pi$
120	BARNHAM	80	IPWA $\pi N \rightarrow N\pi\pi$
228.3 \pm 18.0	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$ (lower mass)
30.0 \pm 6.4	¹ CHEW	80	BPWA $\pi^+ p \rightarrow \pi^+ p$ (higher mass)
120	² LONGACRE	77	IPWA $\pi N \rightarrow N\pi\pi$
150	³ LONGACRE	75	IPWA $\pi N \rightarrow N\pi\pi$

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 $\Delta(1620)$ POLE POSITION

REAL PART VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
1590 to 1610 (\approx 1600) OUR ESTIMATE			
1597 \pm 4	ANISOVICH	12A	DPWA Multichannel
1595	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$
1608	⁴ HOEHLER	93	SPED $\pi N \rightarrow \pi N$
1600 \pm 15	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$

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• • • We do not use the following data for averages, fits, limits, etc. • • •

1587	SHRESTHA	12A	DPWA	Multichannel
1596 ± 7	ANISOVICH	10	DPWA	Multichannel
1615 ± 25	THOMA	08	DPWA	Multichannel
1594	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
1607	VRANA	00	DPWA	Multichannel
1585	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
1587	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
1583 or 1583	5 LONGACRE	78	IPWA	$\pi N \rightarrow N\pi\pi$
1575 or 1572	2 LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

-2xIMAGINARY PART

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
120 to 140 (~130) OUR ESTIMATE			

130 ± 9	ANISOVICH	12A	DPWA	Multichannel
135	ARNDT	06	DPWA	$\pi N \rightarrow \pi N, \eta N$
116	4 HOEHLER	93	SPED	$\pi N \rightarrow \pi N$
120 ± 20	CUTKOSKY	80	IPWA	$\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
107	SHRESTHA	12A	DPWA	Multichannel
130 ± 10	ANISOVICH	10	DPWA	Multichannel
180 ± 35	THOMA	08	DPWA	Multichannel
118	ARNDT	04	DPWA	$\pi N \rightarrow \pi N, \eta N$
148	VRANA	00	DPWA	Multichannel
104	ARNDT	95	DPWA	$\pi N \rightarrow N\pi$
120	ARNDT	91	DPWA	$\pi N \rightarrow \pi N$ Soln SM90
143 or 149	5 LONGACRE	78	IPWA	$\pi N \rightarrow N\pi\pi$
119 or 128	2 LONGACRE	77	IPWA	$\pi N \rightarrow N\pi\pi$

$\Delta(1620)$ ELASTIC POLE RESIDUE

MODULUS $|r|$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT	
18 ± 2	ANISOVICH	12A	DPWA Multichannel	
15	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$	
19	HOEHLER	93	SPED $\pi N \rightarrow \pi N$	
15 ± 2	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
17	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$	
14	ARNDT	95	DPWA $\pi N \rightarrow N\pi$	
15	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90	

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PHASE θ

VALUE ($^{\circ}$)	DOCUMENT ID	TECN	COMMENT	
-100 ± 5	ANISOVICH	12A	DPWA Multichannel	
-92	ARNDT	06	DPWA $\pi N \rightarrow \pi N, \eta N$	
-95	HOEHLER	93	SPED $\pi N \rightarrow \pi N$	
-110 ± 20	CUTKOSKY	80	IPWA $\pi N \rightarrow \pi N$	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-104	ARNDT	04	DPWA $\pi N \rightarrow \pi N, \eta N$	
-121	ARNDT	95	DPWA $\pi N \rightarrow N\pi$	
-125	ARNDT	91	DPWA $\pi N \rightarrow \pi N$ Soln SM90	

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$\Delta(1620)$ INELASTIC POLE RESIDUE

The "normalized residue" is the residue divided by $\Gamma_{pole}/2$.

Normalized residue in $N\pi \rightarrow \Delta(1620) \rightarrow \Delta\pi, D\text{-wave}$

MODULUS (%)	PHASE ($^{\circ}$)	DOCUMENT ID	TECN	COMMENT
38 ± 9	-85 ± 30	ANISOVICH	12A	DPWA Multichannel

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$\Delta(1620)$ DECAY MODES

The following branching fractions are our estimates, not fits or averages.

Mode	Fraction (Γ_i/Γ)
$\Gamma_1 N\pi$	20–30 %
$\Gamma_2 N\pi\pi$	70–80 %
$\Gamma_3 \Delta\pi$	30–60 %
$\Gamma_4 \Delta(1232)\pi$, D-wave	
$\Gamma_5 N\rho$	7–25 %
$\Gamma_6 N\rho$, $S=1/2$, S-wave	
$\Gamma_7 N\rho$, $S=3/2$, D-wave	
$\Gamma_8 N(1440)\pi$	
$\Gamma_9 N\gamma$	0.03–0.10 %
$\Gamma_{10} N\gamma$, helicity=1/2	0.03–0.10 %

$\Delta(1620)$ BRANCHING RATIOS

$\Gamma(N\pi)/\Gamma_{\text{total}}$	Γ_1/Γ
<u>VALUE (%)</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u>
20 to 30 OUR ESTIMATE	
28 ± 3	ANISOVICH 12A DPWA Multichannel
31.5 ± 0.1	ARNDT 06 DPWA $\pi N \rightarrow \pi N, \eta N$
25 ± 3	CUTKOSKY 80 IPWA $\pi N \rightarrow \pi N$
35 ± 6	HOEHLER 79 IPWA $\pi N \rightarrow \pi N$
• • • We do not use the following data for averages, fits, limits, etc. • • •	
33 ± 2	SHRESTHA 12A DPWA Multichannel
23 ± 5	ANISOVICH 10 DPWA Multichannel
22 ± 12	THOMA 08 DPWA Multichannel
31.0 ± 0.4	ARNDT 04 DPWA $\pi N \rightarrow \pi N, \eta N$
34 ± 1	PENNER 02C DPWA Multichannel
45 ± 5	VRANA 00 DPWA Multichannel
29	ARNDT 95 DPWA $\pi N \rightarrow N\pi$
9 ± 2	MANLEY 92 IPWA $\pi N \rightarrow \pi N & N\pi\pi$
60	¹ CHEW 80 BPWA $\pi^+ p \rightarrow \pi^+ p$ (lower mass)
36	¹ CHEW 80 BPWA $\pi^+ p \rightarrow \pi^+ p$ (higher mass)

Note: Signs of couplings from $\pi N \rightarrow N\pi\pi$ analyses were changed in the 1986 edition to agree with the baryon-first convention; the overall phase ambiguity is resolved by choosing a negative sign for the $\Delta(1620) S_{31}$ coupling to $\Delta(1232)\pi$.

$(\Gamma_1\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1620) \rightarrow \Delta(1232)\pi$, D-wave	$(\Gamma_1\Gamma_4)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u>
-0.36 to -0.28 OUR ESTIMATE	
-0.33 ± 0.06	BARNHAM 80 IPWA $\pi N \rightarrow N\pi\pi$
-0.39	^{2,6} LONGACRE 77 IPWA $\pi N \rightarrow N\pi\pi$
-0.40	³ LONGACRE 75 IPWA $\pi N \rightarrow N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •	
-0.24 ± 0.03	MANLEY 92 IPWA $\pi N \rightarrow \pi N & N\pi\pi$

$\Gamma(\Delta(1232)\pi, \text{D-wave})/\Gamma_{\text{total}}$	Γ_4/Γ
<u>VALUE (%)</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u>
60 ± 17	ANISOVICH 12A DPWA Multichannel
39 ± 2	VRANA 00 DPWA Multichannel
• • • We do not use the following data for averages, fits, limits, etc. • • •	
32 ± 2	SHRESTHA 12A DPWA Multichannel
48 ± 25	THOMA 08 DPWA Multichannel

$(\Gamma_1\Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1620) \rightarrow N\rho$, $S=1/2$, S-wave	$(\Gamma_1\Gamma_6)^{1/2}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u>
+0.12 to +0.22 OUR ESTIMATE	
+0.40 ± 0.10	BARNHAM 80 IPWA $\pi N \rightarrow N\pi\pi$
+0.08	^{2,6} LONGACRE 77 IPWA $\pi N \rightarrow N\pi\pi$
+0.28	³ LONGACRE 75 IPWA $\pi N \rightarrow N\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •	
+0.15 ± 0.02	MANLEY 92 IPWA $\pi N \rightarrow \pi N & N\pi\pi$

NODE=B082225;NODE=B082

NODE=B082

DESIG=1;OUR EST
 DESIG=2;OUR EST
 DESIG=181;OUR EST
 DESIG=3
 DESIG=182;OUR EST
 DESIG=4
 DESIG=5
 DESIG=6
 DESIG=185;OUR EST
 DESIG=7;OUR EST

NODE=B082230

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 NODE=B082R1
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OCCUR=2

NODE=B082310

NODE=B082R2
 NODE=B082R2
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NODE=B082R8
 NODE=B082R8

NODE=B082R3
 NODE=B082R3
 → UNCHECKED ←

$\Gamma(N\rho, S=1/2, S\text{-wave})/\Gamma_{\text{total}}$

VALUE (%)	DOCUMENT ID	TECN	COMMENT	Γ_6/Γ
14±3	VRANA 00	DPWA	Multichannel	
• • • We do not use the following data for averages, fits, limits, etc. • • •				

26±2

SHRESTHA 12A DPWA Multichannel

NODE=B082R6
NODE=B082R6 $(\Gamma_i \Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1620) \rightarrow N\rho, S=3/2, D\text{-wave}$ $(\Gamma_1 \Gamma_7)^{1/2}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT	Γ_6/Γ
-0.15 to -0.03 OUR ESTIMATE				
-0.13	2,6 LONGACRE 77	IPWA	$\pi N \rightarrow N\pi\pi$	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.03±0.01	SHRESTHA 12A	DPWA	Multichannel	
-0.06±0.02	MANLEY 92	IPWA	$\pi N \rightarrow \pi N \& N\pi\pi$	

NODE=B082R4
NODE=B082R4
→ UNCHECKED ← $\Gamma(N\rho, S=3/2, D\text{-wave})/\Gamma_{\text{total}}$

VALUE (%)	DOCUMENT ID	TECN	COMMENT	Γ_7/Γ
2±1	VRANA 00	DPWA	Multichannel	

NODE=B082R7
NODE=B082R7 $(\Gamma_i \Gamma_f)^{1/2}/\Gamma_{\text{total}}$ in $N\pi \rightarrow \Delta(1620) \rightarrow N(1440)\pi$

VALUE	DOCUMENT ID	TECN	COMMENT	$\Gamma_7\Gamma_8^{1/2}/\Gamma$
0.11±0.05	BARNHAM 80	IPWA	$\pi N \rightarrow N\pi\pi$	

NODE=B082R5
NODE=B082R5 $\Gamma(N(1440)\pi)/\Gamma_{\text{total}}$

VALUE (%)	DOCUMENT ID	TECN	COMMENT	Γ_8/Γ
0±1	VRANA 00	DPWA	Multichannel	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
9±1	SHRESTHA 12A	DPWA	Multichannel	
19±12	THOMA 08	DPWA	Multichannel	

NODE=B082R9
NODE=B082R9 **$\Delta(1620)$ PHOTON DECAY AMPLITUDES**

Papers on γN amplitudes predating 1981 may be found in our 2006 edition,
Journal of Physics, G **33** 1 (2006).

 $\Delta(1620) \rightarrow N\gamma, \text{ helicity-1/2 amplitude } A_{1/2}$

VALUE (GeV ^{-1/2})	DOCUMENT ID	TECN	COMMENT	Γ_8/Γ
+0.027±0.011 OUR ESTIMATE				
0.052±0.005	ANISOVICH 12A	DPWA	Multichannel	
0.029±0.003	WORKMAN 12A	DPWA	$\gamma N \rightarrow N\pi$	
0.050±0.002	DUGGER 07	DPWA	$\gamma N \rightarrow \pi N$	
0.035±0.010	CRAWFORD 83	IPWA	$\gamma N \rightarrow \pi N$	
0.010±0.015	AWAJI 81	DPWA	$\gamma N \rightarrow \pi N$	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.003±0.003	SHRESTHA 12A	DPWA	Multichannel	
0.063±0.012	ANISOVICH 10	DPWA	Multichannel	
0.066	DRECHSEL 07	DPWA	$\gamma N \rightarrow \pi N$	
-0.050	PENNER 02D	DPWA	Multichannel	
0.035±0.020	ARNDT 96	IPWA	$\gamma N \rightarrow \pi N$	
0.042±0.003	LI 93	IPWA	$\gamma N \rightarrow \pi N$	
0.066	WADA 84	DPWA	Compton scattering	

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 $\Delta(1620)$ FOOTNOTES

¹ CHEW 80 reports two S_{31} resonances at somewhat higher masses than other analyses.
Problems with this analysis are discussed in section 2.1.11 of HOEHLER 83.

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NODE=B082;LINKAGE=C

NODE=B082;LINKAGE=L7

² LONGACRE 77 pole positions are from a search for poles in the unitarized T-matrix; the first (second) value uses, in addition to $\pi N \rightarrow N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis. The other LONGACRE 77 values are from eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.

NODE=B082;LINKAGE=L5

³ From method II of LONGACRE 75: eyeball fits with Breit-Wigner circles to the T-matrix amplitudes.

NODE=B010;LINKAGE=H9

⁴ See HOEHLER 93 for a detailed discussion of the evidence for and the pole parameters of N and Δ resonances as determined from Argand diagrams of πN elastic partial-wave amplitudes and from plots of the speeds with which the amplitudes traverse the diagrams.

NODE=B082;LINKAGE=L8

⁵ LONGACRE 78 values are from a search for poles in the unitarized T-matrix. The first (second) value uses, in addition to $\pi N \rightarrow N\pi\pi$ data, elastic amplitudes from a Saclay (CERN) partial-wave analysis.

NODE=B082;LINKAGE=X

⁶ LONGACRE 77 considers this coupling to be well determined.

$\Delta(1620)$ REFERENCESFor early references, see Physics Letters **111B** 1 (1982).

ANISOVICH	12A	EPJ A48 15	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)	REFID=54041
SHRESTHA	12A	PR C86 055203	M. Shrestha, D.M. Manley	(KSU)	REFID=54862
WORKMAN	12A	PR C86 015202	R. Workman <i>et al.</i>	(GWU)	REFID=54335
ANISOVICH	10	EPJ A44 203	A.V. Anisovich <i>et al.</i>	(BONN, PNPI)	REFID=53280
THOMA	08	PL B659 87	U. Thoma <i>et al.</i>	(CB-ELSA Collab.)	REFID=52087
DRECHSEL	07	EPJ A34 69	D. Drechsel, S.S. Kamalov, L. Tiator	(MAINZ, JINR)	REFID=52105
DUGGER	07	PR C76 025211	M. Dugger <i>et al.</i>	(Jefferson Lab CLAS Collab.)	REFID=52039
ARNDT	06	PR C74 045205	R.A. Arndt <i>et al.</i>	(GWU)	REFID=51535
PDG	06	JPG 33 1	W.-M. Yao <i>et al.</i>	(PDG Collab.)	REFID=51004
ARNDT	04	PR C69 035213	R.A. Arndt <i>et al.</i>	(GWU, TRIU)	REFID=49947
PENNER	02C	PR C66 055211	G. Penner, U. Mosel	(GIES)	REFID=49129
PENNER	02D	PR C66 055212	G. Penner, U. Mosel	(GIES)	REFID=49130
VRANA	00	PRPL 328 181	T.P. Vrana, S.A. Dytman., T.-S.H. Lee	(PITT+)	REFID=47593
ARNDT	96	PR C53 430	R.A. Arndt, I.I. Strakovsky, R.L. Workman	(VPI)	REFID=44675
ARNDT	95	PR C52 2120	R.A. Arndt <i>et al.</i>	(VPI, BRCO)	REFID=44535
HOEHLER	93	πN Newsletter 9 1	G. Hohler	(KARL)	REFID=43821
LI	93	PR C47 2759	Z.J. Li <i>et al.</i>	(VPI)	REFID=43327
MANLEY	92	PR D45 4002	D.M. Manley, E.M. Saleski	(KSA) IJP	REFID=41535
Also		PR D30 904	D.M. Manley <i>et al.</i>	(VPI)	REFID=30071
ARNDT	91	PR D43 2131	R.A. Arndt <i>et al.</i>	(VPI, TELE) IJP	REFID=41467
WADA	84	NP B247 313	Y. Wada <i>et al.</i>	(INUS)	REFID=30072
CRAWFORD	83	NP B211 1	R.L. Crawford, W.T. Morton	(GLAS)	REFID=30070
HOEHLER	83	Landolt-Boernstein 1/9B2	G. Hohler	(KARLT)	REFID=31158
PDG	82	PL 111B 1	M. Roos <i>et al.</i>	(HELS, CIT, CERN)	REFID=41167
AWAJI	81	Bonn Conf. 352	N. Awaji, R. Kajikawa	(NAGO)	REFID=30067
Also		NP B197 365	K. Fujii <i>et al.</i>	(NAGO)	REFID=30068
BARNHAM	80	NP B168 243	K.W.J. Barnham <i>et al.</i>	(LOIC)	REFID=31072
CHEW	80	Toronto Conf. 123	D.M. Chew	(LBL) IJP	REFID=31151
CUTKOSKY	80	Toronto Conf. 19	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP	REFID=30064
Also		PR D20 2839	R.E. Cutkosky <i>et al.</i>	(CMU, LBL) IJP	REFID=40096
HOEHLER	79	PDAT 12-1	G. Hohler <i>et al.</i>	(KARLT) IJP	REFID=30058
Also		Toronto Conf. 3	R. Koch	(KARLT) IJP	REFID=30859
LONGACRE	78	PR D17 1795	R.S. Longacre <i>et al.</i>	(LBL, SLAC)	REFID=30054
LONGACRE	77	NP B122 493	R.S. Longacre, J. Dolbeau	(SACL) IJP	REFID=30051
Also		NP B108 365	J. Dolbeau <i>et al.</i>	(SACL) IJP	REFID=30052
LONGACRE	75	PL 55B 415	R.S. Longacre <i>et al.</i>	(LBL, SLAC) IJP	REFID=30047

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